CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus for optical imaging, comprising:

a) an interferometer;

b) a spectral separating unit which splits signal received from said interferometer into a plurality of optical frequencies; and,

c) a plurality of detectors, each detector capable of detecting at least a portion of said optical frequencies received from said spectral separating unit.

2. The apparatus of Claim 1, wherein said interferometer comprises

d) a means for splitting energy received from a source of electromagnetic radiation into a reference signal and a sample signal;

e) a reference arm providing a reference arm light;

f) a sample arm providing a sample arm light; and,

g) a means for recombining said reference arm light and said sample arm light.

3. The apparatus of Claim 1, wherein each of said plurality of detectors has at least one transimpedance amplifier associated therewith.

4. The apparatus of Claim 1, wherein each of said detectors has at least one band pass filter associated therewith.

5. The apparatus of Claim 1, further comprising at least one source of electromagnetic radiation wherein said source of said electromagnetic radiation has a temporal coherence lower than a predetermined threshold.

6. The apparatus of Claim 5, wherein said source of electromagnetic radiation has temporal coherence of less than about 30 μm.

7. The apparatus of Claim 1, wherein each of said detectors is balanced to be shot noise limited.

8. The apparatus of Claim 1, wherein each of said detectors is balanced to reduce relative intensity noise.

9. The apparatus of Claim 1, wherein said radiation source is selected from the group consisting of a semiconductor optical amplifier, a superluminescent diodes, light-emitting diodes, solid-state femtosecond sources, amplified spontaneous emission, continuum sources, thermal sources, and combinations thereof.

10. The apparatus of Claim 2, wherein said means for splitting is a beam splitter.

11. The apparatus of Claim 2, wherein said means for splitting is a circulator.

12. The apparatus of Claim 2, wherein said means for splitting is utilized in free space using a free space splitter or circulator.

13. The apparatus of Claim 2, wherein said means for splitting is utilized using at least one passive fiber optic component.

14. The apparatus of Claim 2, wherein said splitting means and said recombining means are integrated with one another.

15. The apparatus of Claim 12, further comprising a signal processing unit which is configured to process signal received from said plurality of detectors, and reconstruct longitudinal information from within at least one arm of said interferometer.

16. The apparatus of Claim 15, further comprising an analog-digital converter.

17. The apparatus of Claim 15, wherein said processing unit further includes a digital band pass filter.

18. The apparatus of Claim 15, wherein said processing unit further includes at least one analog band pass filter.

19. The apparatus of Claim 15, wherein said processing unit further includes at least one analog transimpedance amplifier.

20. The apparatus of Claim 1, further comprising a phase modulator.

21. The apparatus of Claim 1, further comprising a demodulator.

22. The apparatus of Claim 1, wherein said reference arm has only a single reference path.

23. The apparatus of Claim 1, wherein said sample arm has only a single sample path.

24. The apparatus of Claim 1, further comprising a means for autoranging.

25. The apparatus of Claim 24, wherein said means for autoranging comprises a processor unit for

a) obtaining a first scan line;

b) locating a surface location "S" of a sample;

c) locating an optimal scan range "R" of the sample;

d) modifying a reference arm delay waveform to provide an output;

e) outputting said output to a reference arm;

f) determining whether said image is complete; and,

g) moving to the next scan line if said image is not complete or remapping said image using said surface S data and said waveform data stored in said memory storage device if said image is complete.

26. The apparatus of Claim 1, further comprising a motionless nonmechanical arrangement for introducing a reference arm delay.

27. The apparatus of Claim 26, wherein said reference arm delay arrangement comprises a means for introducing a frequency dependent phase change.

28. The apparatus of Claim 2, wherein said plurality of detectors comprises a plurality of photodiodes.

29. The apparatus of Claim 2, wherein said plurality of detectors comprises an array of detectors.

30. The apparatus of Claim 29, wherein said array of detectors is a one dimensional array.

31. The apparatus of Claim 29, wherein said array of detectors is a two dimensional array.

32. The apparatus of Claim 29, wherein said detector array is a photodiode array, CCD, CMOS array, active CMOS array, or a combination thereof.

33. The apparatus of Claim 2, wherein said spectral separating unit separates light into orthogonal polarization eigenstates.

34. The apparatus of Claim 33, wherein each of said plurality of detectors comprises two detectors.

35. The apparatus of Claim 1, wherein said spectral separating unit comprises at least one grating.

36. The apparatus of Claim 1, wherein said spectral separating unit comprises at least one prism.

37. The apparatus of Claim 1, wherein said spectral separating unit comprises at least one lens.

38. The apparatus of Claim 1, wherein said spectral separating unit comprises at least one grating and at least one addressable mirror array.

39. The apparatus of Claim 1, wherein said spectral separating unit comprises a linear array of optical filters.

40. The apparatus of Claim 1, wherein said spectral separating unit comprises at least one waveguide filter.

41. The apparatus of Claim 1, wherein said spectral separating unit comprises an array of a plurality of waveguide gratings.

42. The apparatus of Claim 1, wherein said spectral separating unit splits said signal into a plurality of bands whereby each band comprises a set of narrow spectra in a comb-like structure.

43. The apparatus of Claim 1, wherein said processing unit reconstructs the signal from said plurality of detectors in the time domain by mathematical manipulation of each plurality of signals obtained from plurality of detectors.

44. The apparatus of Claim 1, wherein said processing unit reconstructs the signal from said plurality of detectors in the Fourier domain by mathematical manipulation of each plurality of signals obtained from plurality of detectors.

45. The apparatus of Claim 1, wherein said processing unit determines longitudinal information by demodulating reconstructed signal.

46. The apparatus of Claim 1, wherein said plurality of detectors enables processing on individual channels.

47. The apparatus of Claim 46, further comprising an autoranging processor unit for

a) obtaining a first scan line;

b) locating a surface location "S" of a sample;

c) locating an optimal scan range "R" of the sample;

d) modifying a reference arm delay waveform to provide an output;

e) outputting said output to a reference arm;

f) determining whether said image is complete; and,

g) moving to the next scan line if said image is not complete or remapping said image using said surface S data and said waveform data stored in said memory storage device if said image is complete.

48. The apparatus of Claim 1, further comprising a means for tracking the phase of interference fringes.

49. An apparatus for optical imaging, comprising:

a) an interferometer;

b) means for creating a reference arm delay;

c) a spectral separating unit which splits signal received from said interferometer into a plurality of optical frequencies which utilizes a signal received from said means for creating said reference arm delay; and,

d) a plurality of detectors, each detector capable of detecting at least a portion of said optical frequencies received from said spectral separating unit.

50. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises a means for stretching an optical fiber.

51. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises a piezoelectric transducer configured to perform free space translational scanning.

52. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises a phase control optical delay line.

53. The apparatus of Claim 49, wherein said reference arm scans over at least a fraction of the ranging depth equal to one over the number of detectors.

54. The apparatus of Claim 49, wherein said means for creating a reference arm delay further comprises a carrier frequency generator.

55. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises an acoustooptic modulator.

56. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises an electrooptic modulator.

57. The apparatus of Claim 49, wherein said means for creating a reference arm delay comprises a phase control RSOD.

58. The apparatus of Claim 49, wherein said reference arm delay has a distance "z" being less than the range of said sample arm.

59. An apparatus for tracking the phase to reduce signal attenuation due to fringe instability, comprising:

a) at least one phase modulator;

b) an interferometer;

c) at least one light source;

d) at least one detector;

e) a signal processing device for creating a feedback loop.

60. The apparatus of Claim 59, wherein said phase modulator induces a phase delay.

61. The apparatus of Claim 59, wherein said phase modulator induces a path delay.

62. A method for tracking phase in an imaging system, said method comprising the steps of:

a) measuring a signal received from said sample arm;

b) increasing a phase of said signal;

c) measuring a first signal portion of said signal defined as x_1 at at least one peak of said signal;

d) determining whether to increase or decrease the phase of said signal by an incremental amount;

e) after step (d), measuring a second signal partition of said signal following step d); and,

f) if said signal is at its peak, remeasuring said signal and if said signal is not at its peak, repeating steps d) and e).

63. The method of Claim 62, wherein steps (a)-(f) are performed in parallel with other imaging processes.

64. The method of Claim 63, wherein said adjustment of phase "φ" is defined as $A(x_2-x_1)$, where "A" is a constant.

65. The method of Claim 64, wherein step d) further comprises the substeps of d1) determining whether $A(x_2-x_1)$ is within range of said phase modulator; and d2) changing φ by an amount equal to $A(x_2-x_1)$ if $A(x_2-x_1)$ is within said range or changing φ by an amount equal to $A(x_2-x_1)-m2\pi$ if $A(x_2-x_1)$ is outside of said range, where M is an integer greater than 1.

66. The method of Claim 65, further comprising substep d3) remeasuring signal x_1.

67. An apparatus for tracking phase which extended lock range, comprising:

a) a phase tracking subassembly, comprising

i) a phase modulator driver,

ii) a mixer configured to mix signal from at least one detector using modulation frequency from a phase modulator, and to generate an error signal therefrom, and,

iii) a processing unit configured to process said error signal, and to generate an offset voltage.

68. The apparatus of Claim 67, wherein said at least one detector comprises two detector arrays.

69. An apparatus for spectral domain optical coherence tomography imaging with phase tracking, comprising:

a) a phase tracking arrangement, comprising a plurality of detectors; a phase modulator driver, a mixer for mixing signal from said detectors using a with modulation frequency from a phase modulator, and for generating an error signal therefrom, and a processing unit configured to process said error signal, and to generate an offset voltage.

70. A method of increasing sensitivity and signal to noise ratio in OCT and LCI imaging, comprising the steps of:

a) providing a source of electromagnetic radiation;

b) directing said light source through a beam splitter such that a portion of said light is directed to a reference arm delay mechanism and a portion of said light is directed to a sample;

c) passing said portion of said light reflected back from said sample and said portion of said light from said reference arm delay mechanism through a spectral multiplexing assembly;

d) splitting said light from said spectral multiplexing assembly into a plurality of unique frequency spectral band signals;

e) directing each of said band signals to at least one detector;

f) processing said light signals; and,

g) reconstructing longitudinal information from within at least one of said arms of the interferometer based on said processed light signals.

71. A probe useful in optical coherence tomography imaging, comprising:

a) an interferometer;

b) a spectral separating unit which splits signal received from said interferometer into a plurality of unique frequencies;

c) a plurality of detectors, each detector capable of detecting a respective frequency signal received from said spectral separating unit, each of said plurality of detectors having at least one transimpedance amplifier associated therewith and each of said plurality of detectors having at least one band pass filter associated therewith;

d) a processing arrangement for processing signal received from said plurality of detectors; and

e) a display arrangement for displaying said processed signal.

72. A device for optical coherence tomography imaging, comprising:

a) a flexible catheter body having at least one bore therethrough and having proximal and distal ends; and,

b) an optical probe extending through said catheter body such that said optical probe is maintained a distance away from the surface of said tissue when disposed within a patient, said optical probe adapted at its proximal end for connection to an electro-optic image analysis system, said optical probe comprising

i) at least one optical fiber,

ii) a lens element, and

iii) a prism capable of transmitting light from said optical fiber to said tissue surface and receiving reflected light from said tissue surface.

73. The method of Claim 72, further comprising a cable associated with said prism for mechanically rotating said prism about a transverse axis thereof.

74. An apparatus for performing optical coherence tomography imaging, comprising:

a) an interferometer;

b) a plurality of detectors, each detector having at least one transimpedance amplifier associated therewith and at least one band pass filter associated therewith;

c) a processing arrangement for processing signal received from said plurality of detectors; and

d) a display arrangement for displaying said processed signal.

75. The apparatus of 1, wherein said sample is scanned in a series of simultaneous illuminations of substantially all of the area of said sample.

76. An apparatus for optically imaging at least one portion of the sample, comprising:

a. a spectral separating arrangement configured to receive at least one electro-magnetic signal from an interferometer, and to separate the at least one electro-magnetic signal into a plurality of spectral bands, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. a detecting arrangement configured to detect at least one of the spectral bands received from the spectral separating arrangement, and configured to generate a resultant signal for use to image at least one portion of the at least one portion of the sample.

77. The apparatus according to Claim 76, wherein the detecting arrangement includes a plurality of detectors, each of the detectors configured to receive a respective one of the spectral bands.

78. The apparatus according to Claim 77, wherein the detectors digitize the detected spectral bands into digitized signals, and further comprising:

a. a plurality of filters configured to receive the digitized signals, and to band-pass filter the digitize signals.

79. The apparatus according to Claim 78, wherein the at least one electro-magnetic signal includes information regarding at least one portion of an interior of the at least one portion of the sample, and further comprising:

a. a processing arrangement configured to receive the digitized signals, and generate data associated with the at least one portion of the interior of the at least one portion of the sample.

80. The apparatus according to Claim 76, wherein the detecting arrangement generating further signals based on the detected spectral bands, and further comprising a processing arrangement configured to receive the further signals, and generate data associated with longitudinal information extending along the at least one portion of the sample.

81. The apparatus according to Claim 76, wherein the interferometer receives the electro-magnetic signals are generated by an electro-magnetic source.

82. A logic arrangement to provide data associated with optical imaging of at least one portion of a sample, which, when executed by a processing arrangement, configures the processing arrangement to execute the steps comprising of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

83. A method for providing data associated with optical imaging of at least one portion of a sample, comprising the steps of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

84. A storage medium including executable instructions thereon to provide data associated with optical imaging of at least one portion of a sample, wherein, when the executable instructions are executed by a processing system, the executable instructions configure the processing system to perform the steps comprising of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

85. An apparatus for tracking a phase of at least one electro-magnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, comprising:

a. a processing arrangement configured to:

b. receiving information associated with the at least one signal;

c. adjusting the phase of the at least one signal;

d. obtaining position of a signal section of the at least one signal;

e. modifying at least one characteristic of the at least one signal if the position of the signal section is provided away from a peek of the at least one signal by more than a predetermined distance; and

f. repeating steps (d) and (e) until the at least one signal is within the predetermined distance from the peak.

86. The apparatus according to Claim 85, wherein the information corresponds to a combination of at least one of the spectral bands which are separated from the at least one electro-magnetic signal by a spectral separating arrangement.

87. A logic arrangement for tracking a phase of at least one electro-magnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, which, when executed by a processing arrangement, configures the processing arrangement to execute the steps comprising of:

a. receiving information associated with the at least one signal;

b. adjusting the phase of the at least one signal;

c. obtaining a position of a signal section of the at least one signal;

d. modifying at least one characteristic of the at least one signal if the position of the signal section is away from a peek of the at least one signal by more than a predetermined distance; and

e. repeating steps (d) and (e) until the at least one signal is within the predetermined distance from the peak.

88. A method for tracking a phase of at least one electro-magnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, comprising the steps of:

a. receiving information associated with the at least one signal;

b. adjusting the phase of the at least one signal;

c. obtaining a position of a signal section of the at least one signal;

d. modifying at least one characteristic of the at least one signal if the position of the signal section is away from a peek of the at least one signal by more than a predetermined distance; and

e. repeating steps (d) and (e) until the at least one signal reaches a further position that is within the predetermined distance from the peak.

89. A storage medium including executable instructions thereon for tracking a phase of at least one electro-magnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, wherein, when the executable instructions are executed by a processing system, the executable instructions configure the processing system to perform the steps comprising of:

a. receiving information associated with the at least one signal;

b. adjusting the phase of the at least one signal;

c. obtaining a position of a signal section of the at least one signal;

d. modifying at least one characteristic of the at least one signal if the position of the signal section is away from a peek of the at least one signal by a predetermined distance; and

e. repeating steps (d) and (e) until the at least one signal is within the predetermined distance from the peak.

90. An apparatus for tracking a phase of at least one electro-magnetic signal associated with at least one portion of a sample, comprising:

a. a detecting arrangement obtaining at least one first signal comprising a plurality of spectral bands separated from the at least one electro-magnetic signal;

b. a phase modulator driver having a modulating frequency, and configured to modulate the at least one first signal based on the modulating frequency so as to generate at least one second signal;

c. a mixer configured to mix the at least one first signal with the at least one second signal so as to generate a resultant signal, and

d. a processing arrangement configured to generate an offset voltage based on the resultant signal.

91. A logic arrangement for tracking a phase of at least one electro-magnetic signal associated with at least one portion of a sample, which, when executed by a processing arrangement, configures the processing arrangement to execute the steps comprising of:

a. obtaining at least one first signal comprising a plurality of spectral bands separated from the at least one electro-magnetic signal;

b. modulating the at least one first signal based on a modulating frequency of a modulating arrangement so as to generate at least one second signal;

c. mixing the at least one first signal with the at least one second signal so as to generate a resultant signal, and

d. generating an offset voltage based on the resultant signal.

92. A method for tracking a phase of at least one electro-magnetic signal associated with at least one portion of a sample, comprising the steps of:

a. obtaining at least one first signal comprising a plurality of spectral bands separated from the at least one electro-magnetic signal;

b. modulating the at least one first signal based on a modulating frequency of a modulating arrangement so as to generate at least one second signal;

c. mixing the at least one first signal with the at least one second signal so as to generate a resultant signal, and

d. generating an offset voltage based on the resultant signal.

93. A storage medium including executable instructions thereon for tracking a phase of at least one electro-magnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, wherein, when the executable instructions are executed by a processing system, the executable instructions configure the processing system to perform the steps comprising of:

a. obtaining at least one first signal comprising a plurality of spectral bands separated from the at least one electro-magnetic signal;

b. modulating the at least one first signal based on a modulating frequency of a modulating arrangement so as to generate at least one second signal;

c. mixing the at least one first signal with the at least one second signal so as to generate a resultant signal, and

d. generating an offset voltage based on the resultant signal.

94. An apparatus for providing data associated with at least one portion of the sample, comprising:

a. a spectral separating arrangement configured to receive at least one electro-magnetic signal from an interferometer, and to separate the at least one electro-magnetic signal into a plurality of spectral bands, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. a detecting arrangement configured to detect at least one of the spectral bands received from the spectral separating arrangement, and configured to generate a resultant signal for use with the data.

95. A logic arrangement to provide data associated at least one portion of a sample, which, when executed by a processing arrangement, configures the processing arrangement to execute the steps comprising of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

96. A method for providing data associated with at least one portion of a sample, comprising the steps of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

97. A storage medium including executable instructions thereon to provide data associated with optical imaging of at least one portion of a sample, wherein, when the executable instructions are executed by a processing system, the executable instructions configure the processing system to perform the steps comprising of:

a. receiving signals that correspond to spectral bands of the at least one electro-magnetic signal from a detecting arrangement, the detecting arrangement detecting the spectral bands that are separated from the at least one electro-magnetic signal by a spectral separating arrangement, the spectral separating arrangement receiving the at least one electro-magnetic signal from an interferometer, the at least one electromagnetic signal being associated with characteristics of the at least one portion of the sample; and

b. generating the data based on information corresponding to the received signals.

98. An apparatus for tracking a phase of at least one electromagnetic signal so as to reduce an attenuation of the at least one signal due to its fringe instability, comprising:

a. a processing arrangement configured to:

b. receiving information associated with the at least one signal;

c. adjusting the phase of the at least one signal;

d. obtaining position of a signal section of the at least one signal;

e. modifying least one characteristic of the at least one signal if the position of the signal section is away from a peek of the at least one signal by a predetermined distance; and

f. repeating steps (d) and (e) until the at least one signal is within the predetermined distance from the peak.

99. An apparatus for performing optical coherence tomography imaging, comprising:

a. an interferometer providing at least one first signal;

b. at least one detector receiving the at least one first signal, the at least one detector having at least one transimpedance amplifier associated therewith and at least one band pass filter associated therewith so as to generate at least one second signal;

c. a first arrangement configured to process the at least one second signal; and

d. a second arrangement configured to display the at least one second processed signal.

100. The apparatus of Claim 99, wherein said interferometer comprises an arrangement configured to split the at least one first source into a reference signal and a sample signal.

101. A probe for locating atherosclerotic plaque in a blood vessel, comprising:

a. an interferometer;

b. a spectral separating unit which splits signal received from said interferometer into a plurality of optical frequencies; and

c. a detector arrangement capable of detecting at least a portion of said optical frequencies received from said spectral separating unit.

102. An apparatus for delivering a therapeutic agent, comprising:

a. a probe disposed in said housing and comprising:

i) an interferometer,

ii) a spectral separating unit which splits signal received from said interferometer into a plurality of optical frequencies,

iii) a detector arrangement capable of detecting at least a portion of said optical frequencies received from said spectral separating unit; and

b. a conduit cooperating with said probe, and comprising a proximal end for receiving said therapeutic agent and a distal end for delivering said therapeutic agent at a predetermined location, said location being determined by imaging the environment in proximity to said distal end using said probe.